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GB A 2177336 GB A 2171945 EP A1 0143936
EP A1 0133853 EP A 0083707 US 4596352
Note: EP A1 0143936 and US 4596352 are equivalent

(58) Field of search
B3R
Selected US specifications from IPC sub-class
B23K

(54) Ultrasonic welding technique, particularly for welding contact tab to battery electrode

(57) At least one of the two contacting metal areas to be welded are in the form of void-containing disseminated units, such as a bundle of wires, the strands of a wire mesh, the fibres of a metallic fibre mat, or the component elements of a metal foam or sponge. This ensure that the necessary vibration can take place whereby frictional engagement at a multiplicity of points gives rise to heat and fusion with good mechanical and electrical connection.

In one example (Fig. 1a) a bundle of wires (3) has a flattened contact area (4) of separated wires ultrasonically welded to a prepared electrode (1). In another example (Fig. 2b) a metal tab (10) is ultrasonically welded to a compressed zon (8) of a fibrous mat electrode (7) utilizing additionally a wire mesh element (9) whose area corresponds to that of the compressed zone (8). The electrode (7) may be a nickel fibre mat.

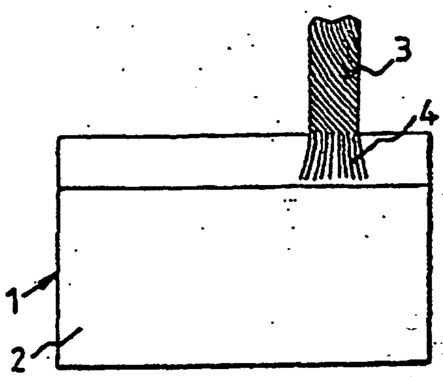

FIG.1a.

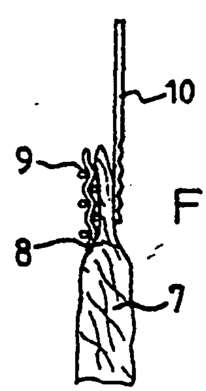

FIG.2b.

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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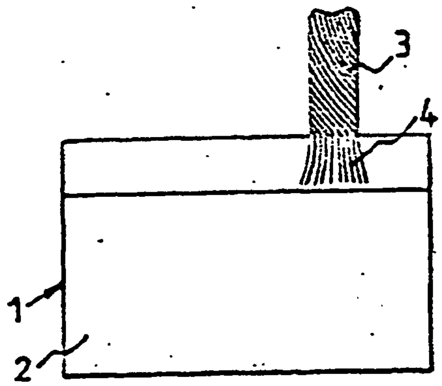

FIG.1a.

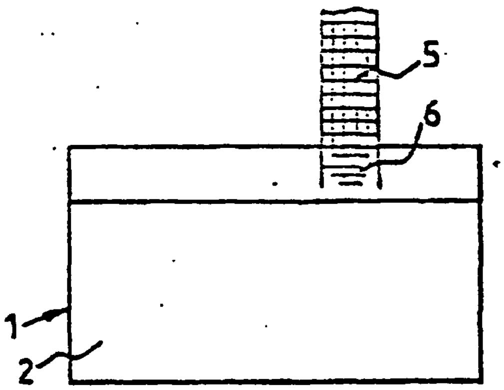

FIG.1b.

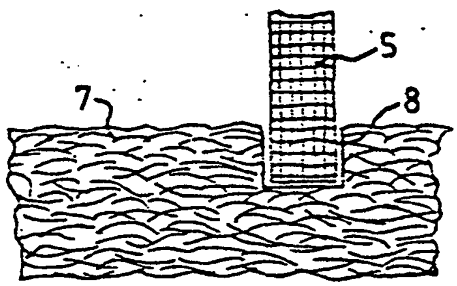

FIG.1c.

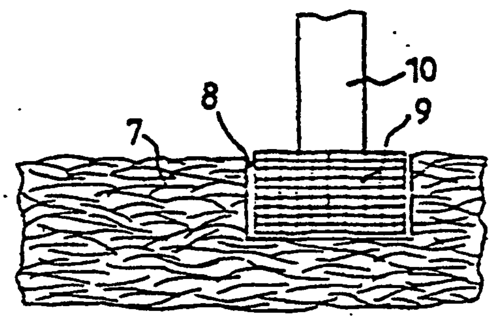

FIG.2a.

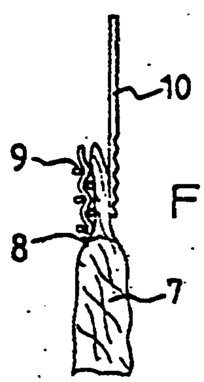

FIG.2b.

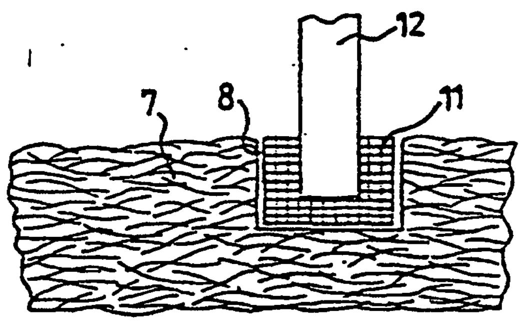

FIG.3.

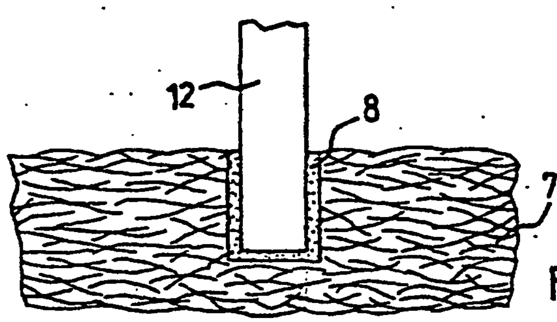

FIG.4.

IMPROVED WELDING TECHNIQUE PARTICULARLY SUITABLE FOR WELDING CONTACT TABS TO BATTERY ELECTRODE

This invention relates to the welding together of two metal areas by ultrasonic energy and is in particular related to the welding of a suitable conductive tab to electrodes. For convenience of description the invention will be generally described with reference to such an area of technology.

In the production of alkaline nickel cadmium cells, perforated metal is used as a support for the active material. For the nickel electrode, nickel powder is sintered onto this perforated metal support and the active ingredients are impregnated into the porous matrix, as is well known in the art. For the cadmium electrode the same procedure may be adopted, or the active ingredients may be mechanically pasted onto a perforated metal sheet or applied by electroplating onto a perforated metal sheet as described in British Patent No. 1 595 835.

In either instance it is necessary thereafter to w ld to the perforated metal sheet a welding tab typically made of pure nickel or of nickel plated steel,

so as to establish the necessary electrical connection to an external battery contact.

The welding of a metal tab to a perforated metal sheets in this context is however a very difficult operation. The main reason for the difficulty is that after sintering, or after the other chemical and mechanical treatment indicated above, the perforated metal is typically covered with loose chemical or metal powders, staining, or metal oxides whereby a good welding bond is very difficult to achieve.

The present invention is concerned with the use of ultrasonic welding techniques to attach the conductive tab to the electrode used as the current collector.

Ultrasonic welding is effected by generating a high-frequency voltage which is converted to mechanical energy by a transducer and amplifier, and is thereafter fed to an ultrasonic horn. The parts to be welded are held between the horn and support (called an anvil) and become physically vibrated against each other by the ultrasonic energy. This vibration causes heat of friction to develop, and this in turn causes the parts to fuse together into a permanent bond.

It has been found that conventional metal welding tabs do not in fact bond satisfactorily with metal sheets by ultrasonics, the reason being that these two metal members do not vibrate sufficiently under ultrasonic welding conditions to generate enough heat to fuse together. The problem is particularly marked with nickel and steel.

The invention consists in a method for the ultrasonic welding of metals in which two areas of metal to be welded together are brought into contact and ultrasonic energy is applied to the contact area, characterised in that at least one of the areas of metal is void-containing and comprises solid metal units capable of relative vibrational movement under such application of ultrasonic energy.

For example, at least one area of metal, or indeed both areas of metal, can be chosen from a bundle of metal wires (preferably from 20 to 250 microns in individual wire diameter) a metal wire mesh (preferably with wires of the same general diameter as indicated above, and preferably of 60 to 200 mesh), a mat sheet of metal fibres, a metal foam, or a metal sponge. We have found that by using such a void-containing composition a sufficient number of welding points are produced by vibration and friction to ensure good mechanical contact and good current collection. Moreover, especially when a

bundle of wires is used, vibration of the material can clean the underlying metal sheet, e.g. the perforated metal sheet, as used in electrode formation, from loose particles of metal or other materials.

Moreover, the total area of bonding can be greater than that normally encountered with conventional resistance welding, again leading to a more positive bond and a better conductivity i.e. lower internal resistance for the electrode incorporating such a bond.

The method of the invention is of particular interest when utilised with a nickel fibre mat. Examples of such material are available under the trade name of "Fibrex". It is also possible to use foam or sponge material as available under the trade name "Metapore". These materials have themselves been proposed as a support material for electrodes, whereby such electrodes, at the area of electrical connection, themselves comprise the void-containing material of the invention. Typically, they can be attached (usually with a prior compression or "coining" to conventional coherent metal surfaces of a welding tag. They can of course also be attached to a wire or mesh substrate of the type discussed above, which produces an even more satisfactory result and as an additional benefit does not lead to so much wear upon

the ultrasonic horn.

One possible form of construction which includes a fibrous metal mat of the electrode is to form a sandwich structure comprising a wire mesh on one surface of the mat, and a conductor tab of a coherent metal surface on the other surface of the mat, the fibrous mat being compressed together between the wire mesh and the tab prior to ultrasonic welding.

The method of the invention is concerned in a preferred embodiment, with the bonding of a conductive tab to an electrode as the type as discussed above. This tab in turn must be bonded to an external contact, this can be done by conventional welding or again by ultrasonics. Other means such as mechanical crimping of the void-containing material could also be used.

The invention will be further described with reference to the accompanying drawings, in which:-

Figure 1a shows diagrammatically the attachment of a wire bundle to a coherent metal electrode;

Figure 1b shows diagrammatically attachment of a wire mesh to a coherent metal electrode;

Figure 1c shows diagrammatically attachment of a wire mesh to a mat of nickel fibre;

Figure 2a shows in front view the sandwich attachment of a coherent metal tab and a wire grid to a mat of nickel fibre;

Figure 2b shows the sandwich attachment of Figure 2a in side view;

Figure 3 shows a yet further embodiment of attachment of both a wire mesh and a coherent conductive tab to a mat of nickel fibres; and

Figure 4 shows a yet further embodiment of an attachment between a tab and an electrode.

In Figure 1a a coherent metal sheet 1, perforated at intervals, is covered and impregnated over the greater part of its area with a layer of active ingredients 2. Such a sheet is a typical electrode component of a battery. It must therefore be connected to a external battery components (not shown) and it is necessary to form a weld between the electrical connector tab and the electrode. In practice, this has been found difficult due to contamination of the surface and due to the characteristics of ultrasonic welding. In the example shown in Figure 1a, however, the difficulties of welding are overcome by providing a bundle of wires 3 flattened as individual wires over a contact area 4. If ultrasonic

energy is applied to this contact area 4, the wires are to some extent free to vibrate, and in doing so clean up the underlying metal area of any adherent particles of metal dust or solid chemicals such as oxides . They also generate heat by such vibration and eventually will fuse to the electrode by a multiplicity of contact points over the whole area . It is to be noted that the area of contact is typically rather greater than that achieved by simple metal-to-metal welding, and that the conductivity is high, leading to a suitably low electrical resistance of the cell, because of the multiplicity of welded contact points.

Figure 1b shows a similar environment using a sheet with active ingredients 2. It however envisages the use of a strip of wire mesh 5 with a contact area 6, again welded by ultrasonic energy in the same manner.

Figures 1a and 1b both involve the use of a disseminated or void-containing metal area in contact with an essentially coherent (even if occasionally perforated) metal sheet. Figure 1c however, shows a different technique in which the electrode itself is in the form of a nickel fibre mat impregnated with the active material. Thus, the electrode 7 itself contains voids and units capable of vibration when an ultrasonic energy is applied. In practice, the electrode 7 is

compressed over a coined area 8 and the wire mesh as in Figure 1b is contacted with this compressed area prior to the ultrasonic energy application. Despite the disseminated nature of both elements, a good multipoint bond and high electrical conductivity is achieved.

Figures 2a and 2b show a refinement of the invention as shown in Figures 1c. In this a sandwich structure is produced. The nickel fibre mat 7 has its compressed area 8 as before, but the wire mesh area 9 is only as such to correspond in size and shape to the compressed area, being utilised on a front surface. Against the rearward surface is pressed a conventional weld tab 10 i.e. with a coherent metal surface so that the compressed fibre mat is sandwiched between the wire mesh and the tab. Exposure of this structure to an ultrasonic welding head causes the various components to weld together. Thus, in this embodiment, the tab itself is of coherent metal while the electrode plate is of a disseminated void-containing nature.

Figure 3 shows a hybrid type of attachment which can be facilitated by use of the present invention. In this, a nickel fibre mat 7 has a compressed area 8 as before. To this compressed area is welded by ultrasonic methods, as described above, an area of wire mesh 10 generally corresponding (as in Figure 2b) to the size of

the compressed area of fibre mat. This structure is then removed from the ultrasonic welding equipment and is subject to conventional welding of a conventional coherent metal weld tab 12 upon the wire mesh. Although the wire mesh is a disseminated or void-containing structure, it is a clean applied element and does not suffer from contamination by metal or oxide powders, conventional welding of the weld tab to the wire mesh can readily take place.

Although Figres 1c, 2a, 2b and 3 all show the attachment of a metal grid to a nickel fibre mat it is of course possible to operate so that an electrode tab of coherent surface nature is welded directly to a nickel fibre electrode. Thus, Figure 4 shows a nickel fibre mat 7, with a covered region at 8 attached directly to a metal tab at 13.

Claims.

1. A method for the welding of metals which comprises bringing into contact two areas of metal to be welded and applying ultrasonic energy to the contact area, in which at least one of the said areas of metal is void-containing and comprises solid metal units capable of relative vibrational movement under such application of ultrasonic energy.

2. A method as claimed in claim 1, in which the other of said areas of metal has a coherent metal surface.

3. A method as claimed in claim 1 in which both said areas of metal are void-containing and comprise solid metal units capable of relative vibrational movement under such application of ultrasonic energy.

4. A method as claimed in claim 1, 2 or 3 in which the said at least one area of metal is composed of a bundle of metal wire.

5. A method as claimed in claim 1, 2, or 3 in which the said at least one area of metal is composed of a bundle of metal wire whereof individual wires are from 50 to 250 microns diameter.

6. A method as claimed in claim 1, 2 or 3 in which said at least one area of metal is composed of a metal mesh.

7. A method as claimed in claim 1, 2 or 3 in which said at least one area of metal is composed of a metal mesh of from 60 to 200 mesh size.

8. A method as claimed in claim 1, 2 or 3 in which said at least one area of metal is composed of metal fibres.

9. A method as claimed in claim 1, 2 or 3 in which said one area of metal is composed of metal foam.

10. A method as claimed in any claim 1, 2 or 3 characterised in that one or both of said metal areas is or are composed of nickel.

11. A method of welding a conductor tab to a coherent battery electrode surface in which the tab is composed at least in part of a bundle of metal wires, comprising causing the tab to contact the electrode surface, and applying ultrasonic energy to vibrate the wires and cause them to weld to the electrode surface.

12. A method of welding a conductor tab to a coherent battery electrode surface in which in that the tab is

composed at least in part of a metal wire mesh, comprising causing the tab to contact the electrode surface, and applying ultrasonic energy to vibrate the mesh and cause it to weld to the electrode surface.

13. A method of welding a conductor tab to a battery electrode in the form of a fibrous mat comprising pressing a portion of said mat to form a compressed or coined area; causing said area to contact a metal conductor, and applying ultrasonic energy to vibrate the fibres and cause them to weld to the metal conductor.

14. A method as claimed in claim 13 in which the metal conductor is in the form of a wire mesh.

15. A method as claimed in claim 14 in which the wire mesh is part of a metal conductor tab.

16. A method as claimed in claim 14 comprising the subsequent step of welding the wire mesh to a metal conductor tab.

17. A method as claimed in claim 14 in which the metal conductor is in the form of a conductor tab with a coherent metal surface.

18. A method as claimed in claim 13 in which the metal

conductor is constituted as a sandwich structure of a wire mesh on one surface of the mat of fibres, and a conductor tab with a coherent metal surface on the other surface of the mat of fibres.

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